# MASSACHUSETTS

# INSTITUTE OF TECHNOLOGY,

## BOSTON.

ENTRANCE HALL; ROGERS BUILDING.

# MASSACHUSETTS

# INSTITUTE OF TECHNOLOGY.

## BOSTON.

*A BRIEF ACCOUNT OF ITS FOUNDATION, CHARACTER, AND EQUIPMENT*

PREPARED IN CONNECTION WITH

**The World's Columbian Exposition.**

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PUBLICATIONS OF THE

# MASSACHUSETTS INSTITUTE

—OF—

# TECHNOLOGY.

ANNUAL CATALOGUE issued in December, containing lists of officers and students, a full statement of the courses of instruction, a register of the graduates with their professional positions, and an account of the Lowell School of Design.

PROGRAM identical with the Catalogue but not containing the registers of students and of graduates.

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In regard to Opportunities for Teachers (in preparation).

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# MASSACHUSETTS

# INSTITUTE OF TECHNOLOGY.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY is a Scientific School, or College of Industrial Science, in which are taught the sciences and their applications to useful arts, through a very wide range. The studies, exercises, and experiments carried on in the school are grouped into thirteen four-year courses as follows: —

## COURSES OF INSTRUCTION.

I. CIVIL ENGINEERING, INCLUDING RAILROAD ENGINEERING, HIGHWAY ENGINEERING, BRIDGE BUILDING, AND HYDRAULIC ENGINEERING.
II. MECHANICAL ENGINEERING, INCLUDING STEAM ENGINEERING, MILL AND LOCOMOTIVE ENGINEERING.
III. MINING ENGINEERING AND METALLURGY.
IV. ARCHITECTURE.
V. CHEMISTRY.
VI. ELECTRICAL ENGINEERING.
VII. BIOLOGY.
VIII. PHYSICS.
IX. GENERAL STUDIES.
X. CHEMICAL ENGINEERING.
XI. SANITARY ENGINEERING.
XII. GEOLOGY.
XIII. NAVAL ARCHITECTURE.

## FOUNDATION.

The Institute was chartered in 1861, and opened to students in 1865. Its founder and first President was Dr. WILLIAM BARTON ROGERS, formerly professor in the University of Virginia, and

Director of the Geological Survey of that State. Dr. Rogers died in 1882. At the time of his death he was President of the National Academy of Sciences. Among Dr. Rogers' co-laborers were some of the most eminent men of the time, notably, Dr. Jacob Bigelow, James B. Francis, George B. Emerson, Erastus B. Bigelow, John D. and Edward S. Philbrick.

## REQUIREMENTS FOR ADMISSION.

The requirements for admission are substantially the same as the requirements for graduation from a good city high school or from the English or scientific department of an endowed academy like Exeter, Andover, or Easthampton. The examinations embrace Arithmetic, Algebra, Geometry, History, French (or German), English Grammar and Composition.

The average age of the entering class is a little over eighteen and a half years.

## DEGREES.

The degree of Bachelor of Science (S.B.) is given for the successful completion of any one of the four-year courses. The degrees of Master of Science and Doctor of Science are offered for the completion of advanced courses of study at the Institute.

## AGRICULTURE.

It will appear from the list of courses already given that the art of Agriculture is not taught at the Institute. The reason is that, when Congress passed the Act of July 2, 1862, providing for the establishment in each State of at least one College of Agriculture and the Mechanic Arts, the Commonwealth of Massachusetts, by Act of April 27, 1863, constituted the Institute of Technology (which had been previously chartered) the College of Mechanic Arts for the Commonwealth, and at the same time established a college at Amherst to promote the interests of agricultural education. But while thus Agriculture is not taught at the Institute as an art, the sciences which especially contribute to Agriculture — that is, Chemistry, Physics, Biology, and Geology — are made the subjects

of distinct courses. Moreover, Topography, Irrigation, Drainage, Highway Engineering, and Road Making (all of them directly tributary to Agriculture) are extensively pursued at the school.

## MILITARY TACTICS.

In accordance with the requirements of the Act of 1862, the Institute gives instruction in Military Tactics, an officer of the regular army being detailed for that duty, with the rank of professor. This branch of instruction is confined to the first year, three exercises being held each week. Arms and equipments are furnished by the United States government. In addition to the Gymnasium of the Institute, the Cadet Battalion is, by the courtesy of the Commonwealth, allowed to drill regularly in the armory of the First Regiment of Massachusetts Militia.

## GRADUATES OF OTHER COLLEGES.

The Institute of Technology generally has in its courses between forty and fifty graduates of other colleges and scientific schools, who come to the Institute to take technical courses. Such students sometimes enter the third year, though more commonly they come in at the beginning of the second year. Persons taking college courses with the purpose of subsequently pursuing technical studies at the Institute, would do well to plan their college work with more or less reference to this consideration; and with that view are invited to correspond with the Secretary of the Institute.

## TEACHERS AT THE INSTITUTE.

Teachers are admitted to the Institute without examination. For those who can only attend in the afternoons and on Saturday forenoon, special provision and arrangements are, so far as possible, made to enable them to take the courses for which they apply.

## WOMEN AT THE INSTITUTE.

The first woman graduate of the Institute was Miss Ellen H. Swallow, now Mrs. Robert H. Richards, instructor in Sanitary Chemistry, who graduated with the class of 1873. Since that time 30 women have received the degree of the Institute, some of them with distinguished honor. Much larger numbers have received instruction in partial courses. The number of women students at the Institute the present school year is 41, some of them graduates of other colleges.

MARGARET CHENEY READING-ROOM; WALKER BUILDING.

The departments which women most frequently enter are Chemistry, Physics, Biology, and Architecture. While in the lines indicated women students almost invariably do good work, it is not expected that their number here will greatly increase. The Institute of Technology is, by the nature of the case, essentially a man's college, though the Corporation and Faculty have seen no reason why any person who wishes to do the work of the school, and is qualified for it, should be excluded by reason of sex.

## THE PURPOSE OF THE SCHOOL.

While the applications of the sciences to the useful arts are extensively taught in the Institute of Technology, the primary purpose of the school is education. Not only are mere knacks and devices and technical methods constantly subordinated to the acquisition of principles, but those principles are studied with the predominant purpose to expand and develop the mind, to exercise the powers and

Fourth Year. Hydraulic Fieldwork Party.

to train the faculties of the pupil. What the Institute aims to do is to graduate those who are, first, well-educated men in all which that term implies, and who, secondly, have studied the problems of some one technical profession, have mastered the scientific principles related thereto, and have had a certain amount of practice in the application of those principles to such problems.

In the four years required for graduation it is sought —

1. To make the pupil observant, discriminating, and exact.

2. To develop in him a taste for research and experimentation on the one side, and for active exertion on the other.

3. To give him the mastery of the fundamental principles of mathematics, chemistry, and physics, which underlie the practice of all the scientific professions.

4. To equip him with such an amount of practical and technical knowledge, and to make him so familiar with the special problems of the particular scientific profession at which he individually aims, as to qualify him immediately upon graduation to take a place in the industrial order. How far this object has been attained through the instruction given in the Institute of Technology, the roll of its alumni and their occupations, as contained in the successive annual catalogues, will tell. As a rule, the graduates of the Institute readily find professional positions where they have an opportunity to show what is in them, and to work their way upward as fast as they deserve. As a rule, also, the course of the graduate of the Institute is one of steady and even rapid promotion.

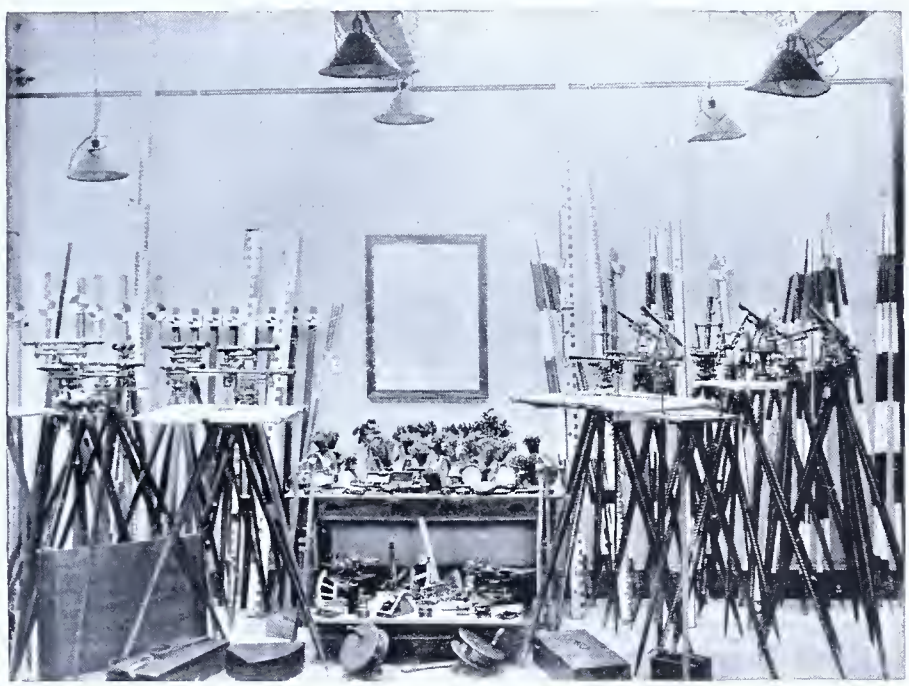
## CHARACTERISTIC FEATURES.

The characteristic and distinguishing features of the Institute may be said to be: —

1. The great number of its teachers and pupils. It is the largest scientific and technical school in the United States, and one of the largest in the world. By the catalogue of 1892–93, the number of students is 1060, and the number of teachers 125. This great body of students come from thirty-nine States and two Territories of the Union, and from seventeen foreign countries.

2. The great variety of its courses, as shown on a preceding page. Some schools devote themselves chiefly or solely to Civil Engineering; other schools to Mechanical Engineering; others still to Civil and Mechanical Engineering; some are predominately Mining schools. This institution is a school of general technology, embracing almost every department of instruction and of experimentation which is found in any scientific or technical school. It is believed that the several departments of the Massachusetts Institute of Technology mutually support each other and induce a healthful emulation, while allowing a degree of differentiation and specialization which would be simply impossible in a

small college, with a less numerous staff of instructors. Thus, at the Institute of Technology, there are not only professors of Civil Engineering and of Mechanical Engineering, but professors or instructors in Mechanism, in Steam Engineering, in Railroad Engineering, in Highway Engineering, in Hydraulic Engineering, in Topographical Engineering, etc. Again, the chemical staff of twenty-two persons is distributed over General Chemistry, Analytical Chemistry, Organic Chemistry, Industrial Chemistry, and Sanitary Chemistry. Several



THIRD YEAR. CIVIL ENGINEERING FIELD INSTRUMENTS.

of these departments have more than one laboratory devoted to their experiments and researches. Thus, there are separate laboratories for water analysis, for gas analysis, for food analysis, for dyeing and bleaching, for organic combustions, etc. In each of these are teachers who are able to give their entire time to instruction and research in a single line.

3. The third characteristic of the Institute of Technology is the unusually large amount of laboratory work that is carried on. Indeed, it was in this school that certain kinds of laboratory work were begun. Here the first laboratory of general chemistry was

organized by Professors Eliot and Storer. Here the first laboratory of general physics was planned by President Rogers, and organized by Professor Pickering. Here the first metallurgical laboratory equipped for the actual treatment of economic quantities of ore was founded by Professor Robert H. Richards. On May 30, 1864, while the first building was going up, President Rogers had proposed a laboratory where the student might "learn practically the methods of estimating motors and machines by the dynamometer, of experimenting on the flow of water, of air, and other gases, and of testing the strength of the materials used in construction;" and in 1873, a mechanical engineering laboratory was opened in the basement of the Rogers Building, the equipment having been planned and set up by Professor Whitaker. This is believed to have been the first engineering laboratory ever established. The first tests of the transverse strength of full-sized timber beams, as part of a scheme of instruction, were those made in the Institute Laboratory of Applied Mechanics, under Professor Lanza. The Laboratory of Electrical Engineering, under the charge of Professor Cross, was the first established, at least in the United States.

This leadership by the Institute of Technology in the advancement of laboratory practice, in the lines mentioned, is significant of the spirit which has here, in all departments, whether of Mechanics, of Physics, of Engineering, of Chemistry, of Biology, or of Architecture, instituted systematic experimental work at nearly every point in every course, to illustrate, to enforce, and to supplement the work of the recitation-room, the lecture-room, and the drawing-room. But while laboratory work is carried so far at the Institute of Technology, it is also true that the student is never allowed to lapse into the state of mind when he can do nothing but laboratory work, — a condition often reached in schools of mere research. This danger has been purposely guarded against; and in each term of his course except the last, the student is called back from the moods of the laboratory to do good lecture-room and recitation-room work, and to give account, clearly and sharply, of what he has been doing in the laboratory.

4. The fourth characteristic of the Institute of Technology to be indicated is the high standard of scholarship which has from the

first been maintained. The Institute stands with the Military Aeademy at West Point and the Naval Academy at Annapolis, in insisting upon the full, actual aecomplishment of all its preseribed work, as a condition precedent to graduation. This school was founded in a eonfident reliance upon the essential manliness of young men, — a belief that, if properly appealed to, and if given work whieh they themselves see to be worth doing, young men ean be brought to labor with enthusiasm and energy; and that lowering the standard

Free-Hand Drawing-Room; Rogers Building.

of requirements is not the way to make a school popular any more than it is the way to make it useful. The unpreeedented resort of students to the halls of the Institute affords sufficient proof that in this view the founders of the Institute of Technology made no mistake. In that spirit the Institute was established, and in that spirit it has been unfalteringly maintained, as a plaee for men to work, and not for boys to play.

5. The fact that, from the foundation of the school, a certain amount of general studies has been made part of every course in the Institute for at least three years out of the four required for gradua-

tion. In some, perhaps most, scientific or technical schools there are no "liberal studies" aside from those of a professional character; in other schools there are no such studies after the first year. The authorities of the Institute of Technology, however, have uniformly maintained the position that some degree of philosophical study should be combined with scientific work.

6. The exceedingly high grade of thesis work which is attained in the fourth year. This would be impossible but for the foundation laid for it by the manner in which the work of the earlier years is done. As an illustration of this feature the Faculty have included in the exhibit the theses presented by the graduating class of 1892, and invite examination of them as affording the best possible means of measuring the work of the Institute of Technology. The theses shown are presented without revision, and are not to be regarded as those of some few superior scholars, but as representing the whole work — the poorest as well as the best — of an entire class at the end of a four-years course. The theses, being a part of the permanent records of the Institute, are necessarily kept under cover to preserve them from injury; but the officer in charge of the exhibit will, on application, present them for examination.

## THE BUILDINGS OF THE INSTITUTE.

The buildings occupied by the Institute are six in number. Numerous photographs of these, presenting both exterior and interior views, will be found in the Institute exhibit. The two buildings first constructed, known severally as the Rogers and the Walker Buildings, are situated upon Boylston Street, one of the great thoroughfares of Boston, upon land conceded by the Commonwealth of Massachusetts. The Rogers Building, completed in 1865, named in honor of William Barton Rogers, first President of the Institute, is 90 by 156 feet on the ground. Its interior structure is somewhat irregular, owing to the introduction of Huntington Hall; but it contains substantially four stories and a basement. It comprises a hall seating nine hundred persons, used for public gatherings and commencement exercises, as well as for lectures of the Lowell Institute, numerous lecture-rooms, recitation-rooms, and

drawing-rooms in the upper stories, while on the first floor are found the departments of Biology and Geology, with the President's and Secretary's offices, and, in the basement, the John Cummings Laboratory of Mining Engineering and Metallurgy.

The Walker Building, on the same square, at the corner of Clarendon Street, built in 1883, has almost precisely the same dimensions on the ground as the Rogers Building, and contains four stories and a basement.

Walker and Rogers Buildings.

The Department of Chemistry occupies, with the Kidder Laboratories and with its recitation and lecture rooms, the two upper stories of the building, together with a laboratory for Industrial Chemistry in the basement. The Department of Physics occupies the remainder of the basement, the entire first floor, and all the second floor not taken by six recitation-rooms for Modern Languages and Mathematics.

In addition to the Rogers and the Walker Buildings, above described, two more of the principal structures of the Institute are situated upon Trinity Place, distant about six hundred feet from the

main Institute square. Of these, the Engineering Building, erected in 1889, is 52 by 148 feet upon the ground, and contains five stories and a basement. The basement and first story are occupied by the engineering laboratories, the four upper floors being the drawing, recitation, and lecture rooms of the Mechanical and the Civil Engineering departments.

Adjoining the Engineering Building is the Architectural Building, erected in 1892. This is 58 by 68 feet upon the ground, and, like the Engineering Building, contains five stories and a basement,

Engineering and Architectural Buildings.

the floors of the two buildings having the same level in each case, with communication by doorways.

In addition to the four buildings mentioned, the Institute has at the foot of Garrison Street a series of shops, which, with the boiler house and chimney, cover about 24,000 square feet on the ground.

The last of the buildings to be mentioned is the Gymnasium, 160 by 50 feet, for athletic and military exercises, besides bath and toilet rooms and a due amount of gymnastic apparatus.

The Institute maintains no dormitories; its students find homes in the city, or in the beautiful suburban towns and cities of the Boston Basin.

## LIBRARIES.

At the Institute of Technology books are regarded as apparatus for immediate use; and the collections are, therefore, placed in direct connection with the several departments.

There are, in all, eleven separate libraries, with an aggregate number of 26,631 volumes. In addition to the card-catalogues of the separate libraries, there is a general card-catalogue, showing in which library any given book is to be found.

The most valuable of the Institute libraries is the William Ripley Nichols Chemical Library, comprising over 5,000 volumes and 2,000 pamphlets. The Engineering Library comprises over 4,000 volumes; the Physical Library more than 3,500, and there is a library of Political Science, comprising over 5,000 volumes. The Architectural Library comprises 1,000 volumes, chiefly illustrated works, and 6,000 photographs.

The several libraries are so arranged and conducted that a student can consult them with the smallest possible loss of time. The students have free access to the card-catalogues and to the shelves. Each library is also used as a reading-room, all the magazines and journals belonging to the department being freely accessible. The number of periodicals received at the Institute, excluding all annuals, is three hundred and sixty-two, forming one of the largest collections of scientific journals, magazines, and reviews to be found anywhere.

## THE LABORATORIES OF THE INSTITUTE.

The chief and dominating feature of the Institute of Technology, from the material point of view, consists of its numerous large and well-equipped laboratories. The buildings of the Institute, in addition to all drawing, recitation, and lecture rooms, and libraries, comprise eight laboratories or groups of laboratories. These are, —

I. The Rogers Laboratory of Physics.
II. The Kidder Chemical Laboratories.
III. The John Cummings Laboratory of Mining Engineering and Metallurgy.

IV. The Engineering Laboratories, including the Laboratory of Applied Mechanics and the Hydraulic Laboratory.
V. The Biological Laboratory.
VI. The Architectural Laboratory.
VII. The Geological Laboratory.
VIII. The Mechanical Laboratories, or Workshops.

The several laboratories may be described in the following terms : —

I. **The Rogers Laboratory of Physics** comprises seventeen separate rooms, all in the Walker Building.

Laboratory of General Physics; Walker Building.

Of these two are lecture-rooms seating 270 and 70 persons respectively, the latter being used jointly by the chemical and physical departments, and eleven are laboratory rooms. There are also the physical library, the apparatus-room, the office of the department, and a study.

The following are the principal rooms used for laboratory instruction : —

1. The Laboratory of General Physics, 108 by 29½ feet, on the first floor, devoted to instruction in the principles of physical measurement. It is supplied with a great variety of apparatus for experimental work in Mechanics, Optics, Heat, and Electricity. The instruction given in this laboratory is designed particularly to teach the student how to use physical measuring apparatus in general, and to make him familiar with the methods of determining various physical constants.

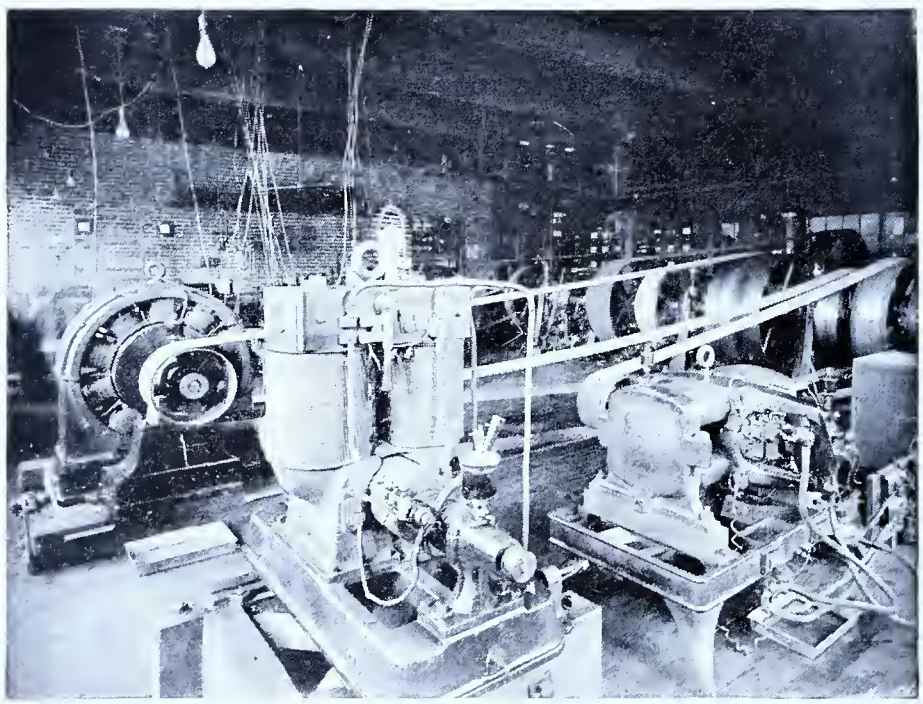
2. The Laboratory of Electrical Measurements, also on the first floor and of the same size as the preceding, which is devoted chiefly to advanced electrical work carried on by the students in Electrical Engineering, Physics, and Chemistry. In this room will be found an extremely large and valuable collection of electrical measuring apparatus of a character suited for delicate testing. Instruments for the determination of electrical resistance and capacity, electromotive force and current, for the calibration of galvanometers, for the study of the magnetic properties of iron and steel, are in constant use by the more advanced students. Here are also the batteries for testing, amounting to nearly 200 cells. Much of this apparatus is original in design. A considerable amount of research and thesis work is carried on in this laboratory.

3. The Dynamo-room in the basement, 40 by 40 feet, is provided with a Westinghouse engine of 75 horse-power, the sole use of which is to furnish the power to drive the plant of dynamos. This plant, besides a number of smaller machines, comprises a 500 light alternating current Thomson-Houston dynamo, with transformers, a 150 light Edison dynamo, a 200 light Thomson-Houston direct current dynamo, a 60 light Weston dynamo, a 3 arc-light Brush dynamo, a United States 300 Ampere low voltage dynamo for electrolytic work, and a Siemens' alternating arc-light dynamo. From time to time other large machines are temporarily placed here for purposes of study by the students. The wires from this room are carried to all parts of the building for experimental purposes, as well as for use in illumination. The illuminating circuits are, however, capable of instant connection with the mains of the Edison Illuminating Co., so that all of the dynamos are available at all times for purposes of instruction. The dynamo-room is also furnished with a

great variety of apparatus for measurements of the current, electromotive force, and out-put of the dynamo machines.

4. The Laboratories of Electrical Engineering comprise:

A room $83\frac{1}{2}$ by $29\frac{1}{2}$ feet in the basement, devoted especially to thesis and other work in dynamo machinery. It contains a cradle dynamometer for the mechanical measurement of power consumed by dynamo machines, a large ice-calorimeter for testing transformers, a 500 volt storage battery for purposes of calibration, a closed air-

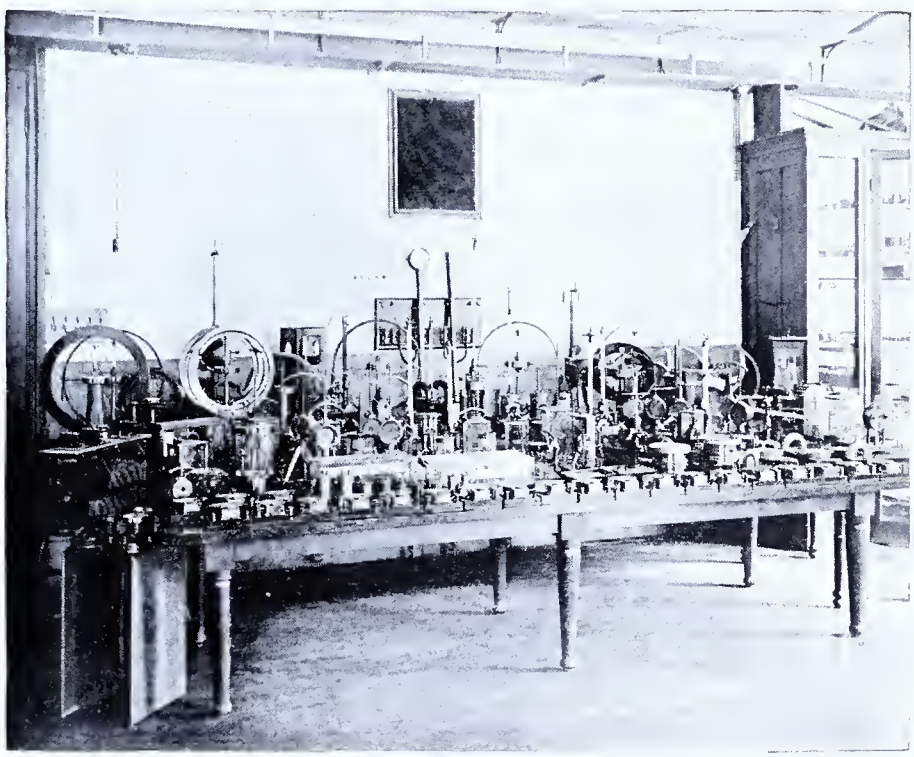


Dynamo-Room; Walker Building.

chamber, 8 by 8 feet, for testing ventilating fans and blowers, and several electro-motors of various capacities. Here is also placed an extensive collection of railway signalling apparatus used in the instruction of the mechanical, civil, and electrical engineering students. In this room much of the testing of electro-motors, in connection with thesis work, is carried on. Here is also found a photometry room, for the purpose of testing arc and incandescent lights, and the workshop of the mechanician of the Rogers Laboratory, used also by the students.

A room $36\frac{1}{2}$ by 29 feet, opening from the dynamo-room, is used almost entirely for research in connection with the theses.

5. A room, $61\frac{1}{2}$ by $29\frac{1}{2}$ feet, also in the basement, contains dark rooms fitted up for photographic work, and also an additional photometry room. Here also is carried on the laboratory work in heat measurements of the students in chemical engineering. The storage batteries are also placed here, and such apparatus as is used in testing them. Various other electrical experiments are also carried on in this room.



Physical Apparatus: Galvanometers.

6. The Acoustic Laboratory, 33 by $29\frac{1}{2}$ feet, is situated on the second floor. This is designed especially for acoustic and telephonic study and research. It is furnished with special telephone and electric light and power currents, and a constant-pressure blast. There are electro-motors and all other needed facilities for the electrical driving of sirens and like apparatus. In this laboratory is placed the extensive collection of acoustic apparatus belonging to the Institute.

7. The Optical-room, 29½ by 29 feet, adjoins the Acoustic Laboratory east and south, and is particularly designed for such work as may require the use of sunlight. It is also employed for other advanced work as occasion requires. The cabinet of optical apparatus is located here.

8. A room, 23 by 10 feet, on the same floor as the preceding, is fitted up for the purpose of the construction and test of resistance coils. It contains a constant temperature tank with the standard Wheatstone's bridge, and the necessary galvanometers and accessory apparatus.

9. A small room, 16 by 15½ feet, opening from the Acoustic Laboratory, contains various electro-dynamometers, and like apparatus used in connection with measurements upon self-induction.

II. **The Kidder Laboratories of Chemistry** in the Walker Building comprise eighteen working laboratories, four lecture-rooms, a library and reading-room, balance-rooms, offices, and supply rooms, — in all, thirty rooms.

1. The Laboratory of General Chemistry is 84.5 by 39.5 feet. It has 133 working desks. Under each desk there are three complete sets of drawers and cupboards, so that the laboratory has accommodations for 400 students. Since the classes in this laboratory are limited to about 50 students working at one time, the three students who have a desk in common never interfere with each other. The actual number of students working in this laboratory during the year 1892–93 was 385.

This laboratory is for beginners in chemistry, and the exercises during the first term of the first year are designed not only to make the student familiar with chemical manipulation, and to teach him fundamental chemical facts, but also to train him in accurate habits of observation. In the second term of the first year, the elements of qualitative analysis are taught in this laboratory.

2. The Laboratory of Analytical Chemistry is likewise 84.5 by 39.5 feet. It has 108 desks, 4.8 feet long, and each desk is provided with cupboards and drawers in which a large amount of apparatus can be stored.

These laboratories of General and Analytical Chemistry are on the

fourth (top) floor of the Walker Building, and each is lighted on three sides by 23 windows. The rooms are 17 feet high, and have large sky-lights in the roof. They are provided with all the permanent fittings found in modern chemical laboratories for accurate and rapid work. The Analytical Laboratory is provided also with suitable electrical currents and apparatus for electro-chemical analysis. The ventilation of these laboratories (as in all the rooms of the Walker Building) is effected by forcing in moderately warmed air by

Laboratory of Analytical Chemistry; Walker Building.

a powerful fan in the basement. The outlet of this air in the laboratories is through the hoods which line the walls. The amount of air passing through the laboratories is such as to secure a total change once in seven minutes. In consequence of this unusually perfect ventilation it is possible to conduct, without annoyance or injury, many chemical operations in the open laboratory, which in most chemical laboratories must be confined to closed hoods. In this laboratory there is a unique evaporator designed by Mr. S. H. Woodbridge, of the Institute, in which evaporations of water and other

liquids can be very rapidly performed. It consists of a combination of a steam bath and a current of warm air.

3. Adjoining the Analytical Laboratory is a room, 31.6 by 11.7 feet, used exclusively for volumetric analysis. In this room, which is painted entirely in white, 21 students can work at the same time.

4. The Organic Laboratory, also on the fourth floor, is 29.2 by 36 feet. It has desks for 26 students, and is provided with all the conveniences and delicate apparatus required for work in organic chemistry. Adjoining is a laboratory, 6 by 26 feet, arranged exclusively for organic combustions. It has all the requisite fittings for gas, oxygen, blast, and suction to operate five furnaces at one time. On the roof above the Organic Laboratory is an enclosed room, 19.7 by 23 feet, in which chemical operations of a dangerous or noxious character can be performed.

Four small laboratories, 17.5 by 14.5 feet each, are also on the fourth floor, for the use of the staff of instruction.

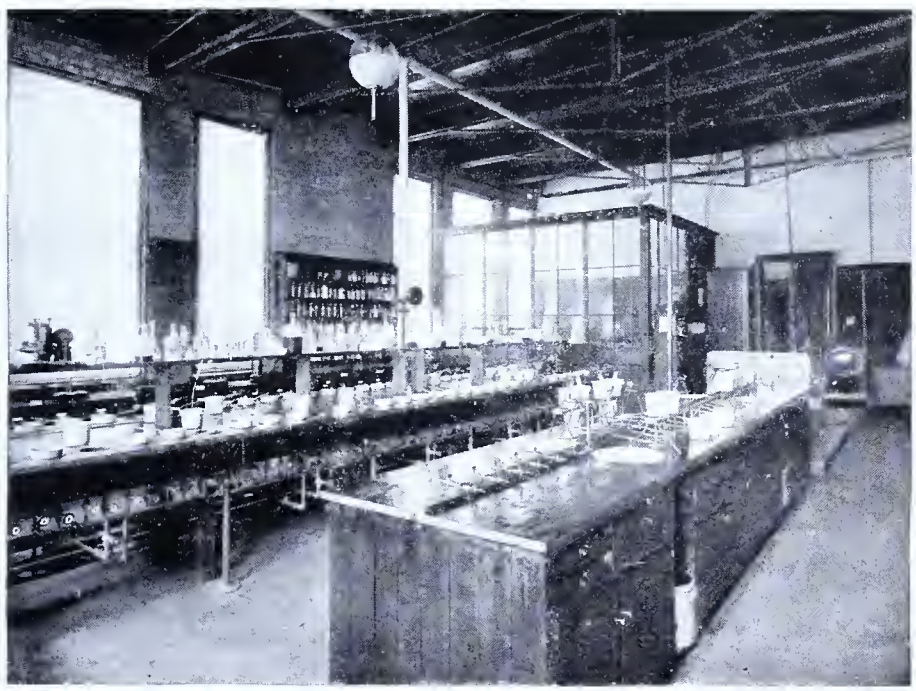
5. The Balance-room, communicating directly with the Analytical and Organic Laboratories, is 12.2 by 32 feet; it contains 22 high-grade analytical balances.

6. Sanitary Chemistry. There are two laboratories on the third floor, respectively 39.3 by 39.5 feet, and 37.3 by 29.5 feet. The instruction in Sanitary Chemistry comprises the examination of food products, such as flour, butter, milk, and the analysis of air and water, and the study of sanitary problems. In these laboratories, under the charge of the head of the chemical department and the instructor in Sanitary Chemistry, has been conducted the great investigation of the Massachusetts Board of Health into the natural waters of the State. In the course of this investigation, which is still in progress, there have been analyzed, since 1887, over 10,000 samples of water.

7. The Laboratory for Gas Analysis occupies a room, 25.5 by 10.5 feet, partitioned off from one of the Sanitary Laboratories. It contains a collection of the best modern apparatus for the analysis of gases. The instruction in this department includes an extended course in gas analysis for students of Chemistry, and a shorter course for the students in Mechanical Engineering. The great importance

which attaches to the economic utilization of fuel renders the course in the analysis of furnace gases particularly valuable to the engineer.

8. Three chemical laboratories on the third floor are provided for the head of the department of Chemistry, for the Professor of Organic Chemistry, and for the Professor of Industrial Chemistry, who is the head of the department of Chemical Engineering. These three laboratories, which are respectively 37.3, 24.3, and 18.3 by 29.5



Laboratory of Textile Coloring; Walker Building.

feet, are used also by students engaged, directly under the professors, in original investigation.

9. The Laboratories of Industrial Chemistry comprise a large room in the basement for the manufacture of chemicals on a semi-industrial scale, and a laboratory for textile coloring on the third floor. The first mentioned is a room 59 by 29.5 feet, which contains kettles of various patterns, stills, presses, tanks, centrifugal dryers, filter presses, crystal dryers, etc. The laboratory of textile coloring, 39.3 by 29.5 feet, contains a large number of jacketed kettles, baths, and dye tubs, squeeze rolls, steamer, ager, and drier,

and a two-color printing-machine. It is provided with arc-lights for working after dark.

10. A room, 39 by 14 feet, on the second floor, is fitted for the special purpose of instruction in the optical analysis of sugar.

There is a large and readily accessible store-room, 25.2 by 29.5 feet, on the third floor, for chemicals and apparatus, another in the basement, and two supply-rooms on the fourth floor. Two underground vaults, respectively 37 by 9 feet, and 60 by 32.5 feet, are

Laboratory of Industrial Chemistry; Walker Building.

provided for the storage of apparatus in original packages, for carboys, inflammable liquids, etc.

The Chemical Library and Reading-room, 32 by 17 feet, is situated between the Analytical and Organic Laboratories on the fourth floor.

The principal chemical lecture-room is 45 by 40.5 feet, and is fitted with 220 rising seats. Another lecture-room, 28 by 21 feet, has seats for 40, and a third room, for still smaller classes, accommodates 10 students. A lecture-room, 35 by 25.5 feet, with a seating capacity of 65, is used by both the chemical and physical departments.

111. **The John Cummings Laboratory of Mining Engineering and Metallurgy,** in the basement of the Rogers Building, comprises laboratories for milling, for concentrating, and for smelting ores, as well as for testing them by an assay and by the blowpipe, and a library comprising the most important literature of the subject.

Smelting Laboratory: Watching for the Blick.

The Blowpipe-room, 28 by 32.5 feet, is provided with tables for 24 students, and with the apparatus and supplies, balances, reagents, water, and gas, needed for the determination of minerals, as well as for the assay of silver by the blowpipe.

The Room for Assaying is 28.3 by 35.65 feet, and contiguous with it is a balance-room, 13.6 by 16.7 feet, for fine balances. This laboratory is supplied with desks for fifty students, although only ten work at a time. There are ten crucible furnaces, seven muffles, with

the necessary stock of ore samples, ore and reagent balances, as well as fine button balances.

The Milling-room is 91.7 by 27.9 feet, and can be used by a class of fifteen students. It is supplied with fine apparatus for milling gold and silver ores by the various processes of amalgamation, lixiviation, and chlorination. This laboratory is also well provided with the machinery for concentrating gold, silver, copper, lead, and zinc ores, and has a complete plant for experimenting on the depositing and refining of metals by electricity.

The Smelting-room is 55 by 35.7 feet, and large enough for a class of fifteen students. This laboratory has complete apparatus for roasting and smelting ores, and refining metals in quantities of from 500 to 6,000 lbs., according to the process.

The most noteworthy parts are the water-jacket furnace and the Brückner roasting cylinder. Attached to the laboratory are: —

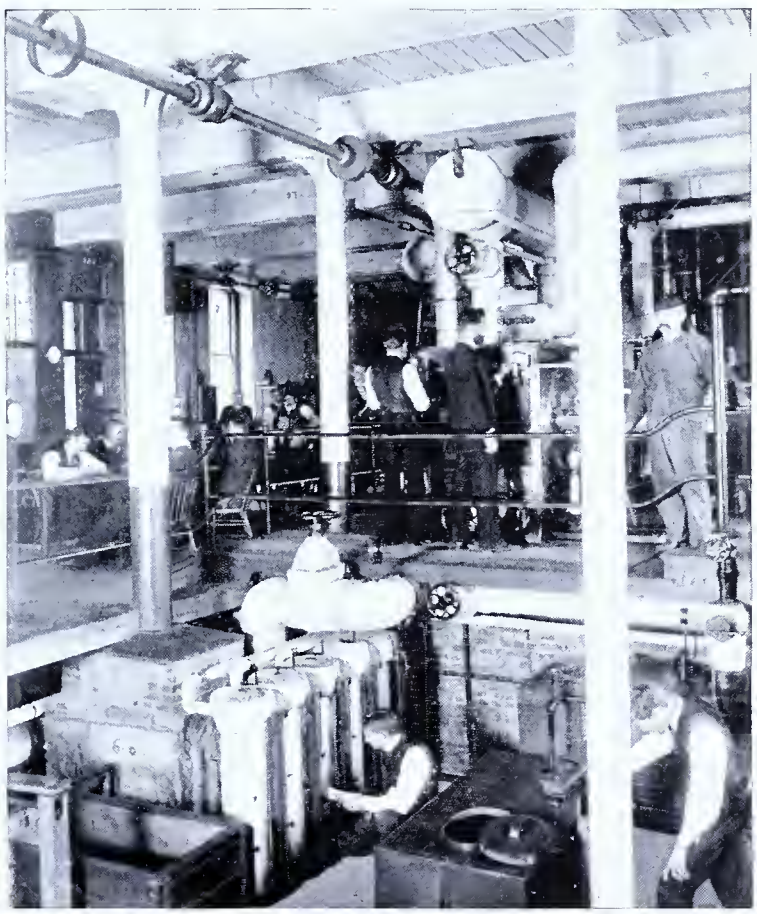
1. A Library, 22.6 by 15.5 feet, containing over 3,000 volumes, including all the prominent mining and metallurgical periodicals in English, French, and German.
2. A Private Laboratory, 16.7 by 14.2 feet, for chemical and physical experiments on ores.
3. A Supply-room, 15.8 by 10 feet, for small apparatus and chemicals.
4. An Office for the instructors.
5. A Toilet-room, 21.5 by 20 feet, with abundant supply of water, and with a hanging closet for each student in the department.

IV. **The Engineering Laboratories** occupy the two lower floors of the Engineering Building on Trinity Place, and comprise laboratories of steam engineering, of hydraulics, a laboratory for testing the strength of materials, and a room containing cotton machinery.

The laboratories of steam and hydraulics occupy a portion of the lower floor, 50 by 100 feet, and the central portion of the floor above, 50 by 70 feet. The heavier pieces of apparatus and those requiring special foundations are placed on the lower floor.

1. The Steam Laboratory. The most prominent feature of this is the 9, 16, and 24 by 30 inch, Allis triple-expansion engine, having a capacity of about 150 horse-power when running triple, with 150 lbs. initial pressure in the high-pressure cylinder. This

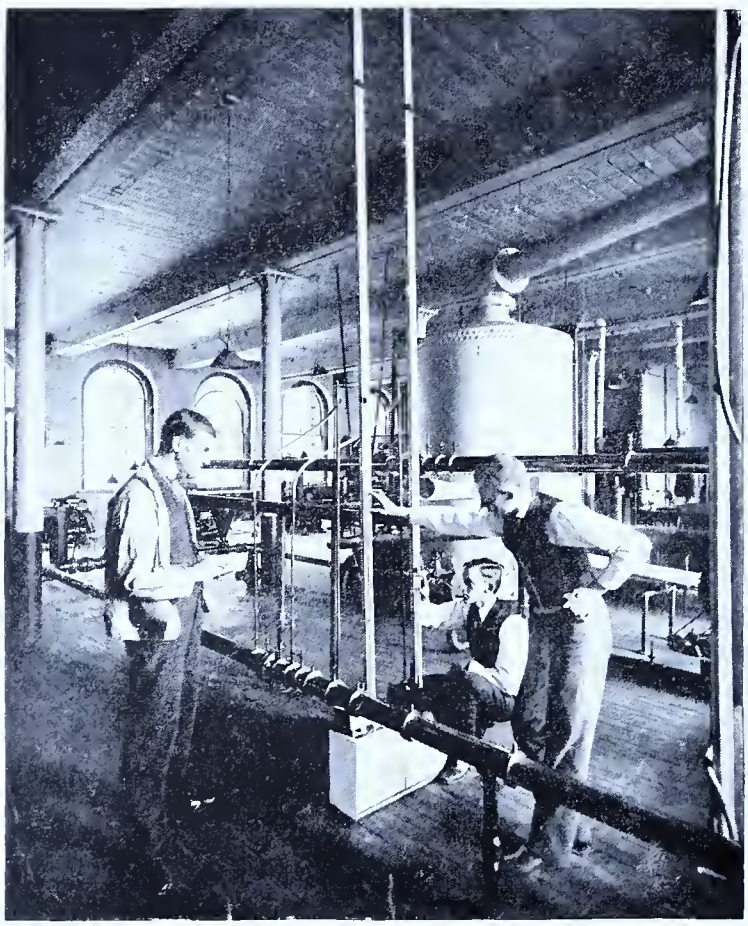
engine is arranged so that any cylinder may be used single, or compound with either of the others. Also, each cylinder may be jacketed, wholly or in part, and the receiver may also be jacketed. The engine is connected with a large surface-condenser and other apparatus necessary to adapt it to the purposes of accurate experiment.



Engineering Laboratory: An Engine Test.

The laboratory also contains a 16 horse-power Harris-Corliss engine and an 8 horse-power engine used for giving instruction in valve-setting. In addition to these, there is a great variety of apparatus, including condensers, calorimeters, injectors and ejectors, steam pumps, etc., directly connected with studies in steam, also apparatus for testing the efficiency of transmission of power and for measuring the power transmitted.

All the apparatus is arranged for experimental purposes; and each student takes some part in the experiments on each piece of apparatus. The results of each test are calculated by each student, and also by the instructors in charge. Many of the tests not only give the student training but contribute to scientific knowledge.



Hydraulic Laboratory: Engineering Building.

2. The Hydraulic Laboratory contains a closed tank, 5 feet in diameter and 27 feet high, extending from the basement under the lower floor to the upper part of the room on the second floor. This is connected with a stand-pipe, 10 inches in diameter and over 70 feet high, so arranged that the water may be maintained at any desired point, glass gauges along the stand-pipe serving to measure the height. The stand-pipe is connected with a steam pump, with a rotary pump, and with the city supply. On the sides of the large

tank are the connections for the various hydraulic apparatus, including apparatus for measuring the flow over weirs; through various sizes and shapes of orifices; through hose-nozzles; through different sizes of pipe, with the several varieties of obstructions that occur, — namely, diaphragms, couplings, elbows, T's, bends, valves, etc. Also connected with the tank, or with a centrifugal pump, is a Swain Turbine, so arranged that measurements can be made of the power transmitted under various heads and with different openings of gate.

The water used in the various hydraulic apparatus is conducted to a well in the basement, from which the pumps of the laboratory obtain their supply.

This laboratory also contains a Venturi meter, a Worthington meter, a Pelton water-motor, a hydraulic ram, a steel calibrating tank of 280 cubic feet capacity, Pitot tube apparatus for measuring the distribution of velocity in pipes and jets, and instruments for measuring the exact size of jets. The laboratory is also equipped with a variety of mercury gauges, weirs, standard orifices, mouthpieces, diaphragms, nozzles, etc., for experiments with flowing water under all conditions.

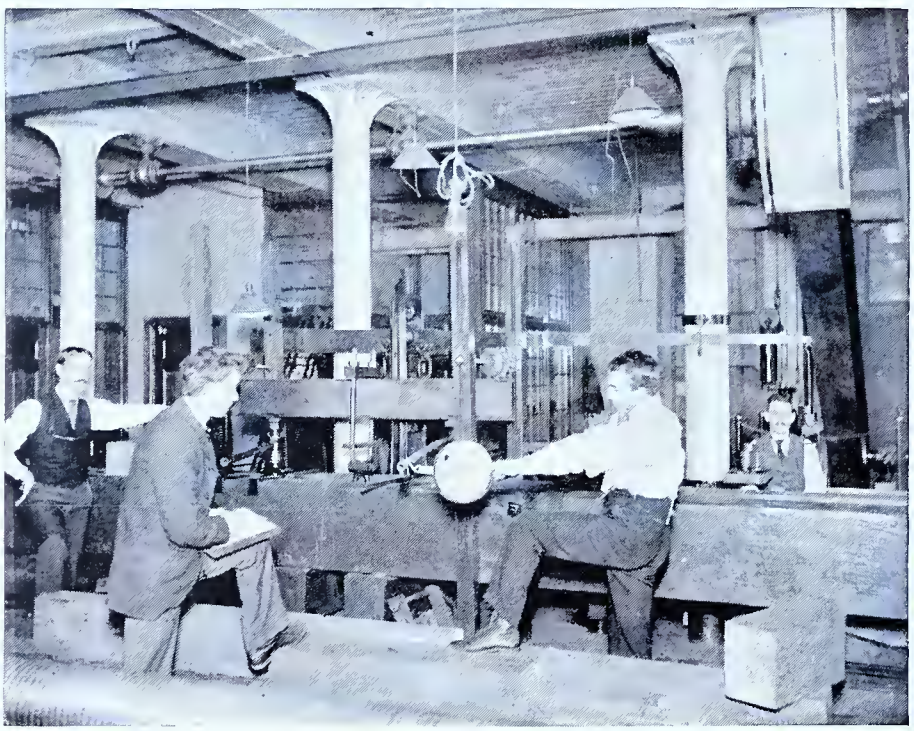
As in the steam laboratory, tests are carried on by the students, each one having some part in all, and calculating the results.

3. The Laboratory for testing the Strength of Materials occupies, on the first floor, 50 by 50 feet, and a room of the same size, directly above, on the second floor. It contains an Emery testing-machine of a capacity of 300,000 pounds, capable of containing a compression piece eighteen feet long, and a tension piece twelve feet long; also an Olsen testing-machine, with a capacity of 50,000 pounds, and a variety of other apparatus for testing the tensile and compression strength of materials, — steel, wrought iron, cast iron, rope, wire, hydraulic cement, etc., and the transverse strength of iron and wood beams up to twenty-five feet in length.

These tests are all conducted on a practical scale, and many have contributed largely to our knowledge of the strength of materials as used in construction. In addition to the regular prescribed course of instruction in the laboratories, a large amount of original investiga-

tion is carried on by the students in the fourth year in connection with the thesis work.

4. A room on the second floor, 50 by 30 feet, contains cotton machinery, — namely, card, drawing-frame, speeder, fly-frame, ring spinning-frame, and mule. These machines are used by the students in the second term of the second year as examples of complicated mechanisms, and are studied as such in connection with the previous



Applied Mechanics Laboratory.
The Fairbanks Testing-machine.

course in the elements of mechanism. They are also used by the students taking the option of Mill Engineering, in connection with a study of the processes of cotton-spinning, and especially for experimental work in connection with theses.

V. **The Biological Laboratory** of the Institute occupies a large room, 30 by 90 feet, on the first floor of the Rogers Building, extending across the entire end of the building, on the Newbury Street side, with large windows opening mainly to the north.

The laboratory, as a whole, is devoted to the practical examination and investigation of the physical, chemical, and physiological aspects of those problems concerning living organisms which naturally fall within the scope of a scientific institution. The most important courses carried on in the laboratory are : —

1. Microscopy, for which special provision is made in a large supply of working instruments. Every student is provided with one

Biological Laboratory; Rogers Building.

of these, and becomes accustomed to its use under expert supervision in examinations of starches, sands, cotton, silk, wool, and other fibres ; yeasts, adulterated foods, etc.

2. General Biology. That portion of the laboratory devoted to the work in Elementary Biology (including General Biology, General Zoölogy, and General Botany) contains places for twenty students.

The equipment of representative material, of charts, of dissecting and microscopical apparatus, and of all necessary instruments, is ample, and well adapted to develop personal skill in the student as well as the power of close and accurate observation.

3. Comparative Anatomy and Embryology. For the numerous and detailed dissections and the carefully prepared specimens required in these subjects there is special provision. Here also are places for twenty students, with large tables for the prepared material and with refrigerators for fresh material.

4. Physiology and Histology. For the actual appreciation of the actions and reactions of organisms, for the study of their effects and of their powers, a great deal of apparatus, as well as much labor on the part of the student, is required. That section of the Biological Laboratory devoted to these subjects is, therefore, essentially a workshop, provided with instruments, and having places for ten students. Here the student learns the technique of tissue-dyeing, of ribbon sectioning, of electrical dealings with muscle and nerve; the hydraulics of the circulation; artificial digestions and the separation of soluble ferments; and the physiology of opties and acoustics.

5. Micro-Organisms and Bacteriology. The most important feature of the biological laboratory work is the opportunity offered for thorough practical acquaintance with the lower and obscurer forms of life. These are not only of great general interest, but of immense and increasing economic importance. Vast industries, connected with food-preserving, canning, vinegar-making, and the like; important public affairs, such as water supply and milk supply; sanitary interests, such as efficient ventilation, dust-destruction, garbage-disposal, and mere cleanliness, — these and many more conditions profoundly affecting the welfare of the community depend in the last analysis for their scientific administration upon an acquaintance with moulds, ferments, fungi, algæ, bacteria, and other low forms of life. For the study of these the laboratory is thoroughly equipped with special microscopes and objectives, thermostats, culture-rooms, etc. Here the students learn how to prepare culture media; to plant, to collect, to separate, identify, and describe species; to test the value of germicides and antiseptics;

to examine and test natural waters; to discover, enumerate, and classify the microscopical organisms in reservoirs, rivers or lakes, and in sewage. A portion of the biological work of the State Board of Health of Massachusetts is also carried on in this laboratory.

VI **The Architectural Laboratory.** The laboratory in the basement of the Architectural Building has its floor directly on the concrete,

Architectural Drawing-Room.

and has a clear height of $17\frac{1}{2}$ feet; is 52 feet long, and 25 feet wide. This height allows an effective system of plumbing, for testing purposes, to be set up. On a four-inch main are arranged four offsets, in the same relative position as they are placed in regular house plumbing. This scheme is intended to show the effect upon traps of a solid column of water as it passes down the main. There is also placed near the ceiling a tank with an inch and a half outlet. This is used in testing the regular inch and a half wastes with their traps. The four-inch main is fifty-five feet long, and on top of it is a reservoir holding seven hundred gallons of water. In

this laboratory are carried on the experiments and tests in lines, cements, etc., and practical lessons are given in the mixing of mortars. The course in clay-modelling is also given here. At one end of this room is the engine and fan used for the heating and ventilation of the building.

VII. **The Geological Laboratories.**

1. The Laboratory of Mineralogy, Lithology, Structural Geology, and Economic Geology, Room 12, Rogers Building.

Capacity, 36 students.

The apparatus used in this laboratory includes two lithologic microscopes, a reflecting goniometer, three hand-goniometers, dichroscope, clinometer, specific gravity balances, zoetrope, etc.; also a complete series of crystal models, of glass and wood, about 400 in all, about 125 crystallographic charts, and about 175 charts illustrating structural geology; a series of wooden models illustrating geologic structure, etc.

The collection of specimens forming part of the laboratory equipment is quite extensive, embracing: —

(*a*) About 250 trays of minerals specially prepared for laboratory work, amounting to nearly 4,000 specimens; (*b*) 40 examination trays of minerals, containing 1,000 specimens; (*c*) A students' reference collection of minerals, — 1,000 specimens in a case of 24 drawers; (*d*) A systematic collection of minerals, filling 35 drawers and 2 cases of shelves; (*e*) 160 trays of rocks specially prepared for laboratory work in lithology, containing 1,920 specimens; (*f*) 60 examination trays of rocks, containing about 600 specimens; (*g*) A students' reference collection of rocks of 250 specimens in 12 drawers, (*h*) A systematic lecture collection of rocks, filling 32 drawers and a set of shelves; (*i*) 400 thin sections of rocks for the microscope; (*j*) 40 drawers and one glass case of specimens illustrating structural geology: (*k*) About forty dressed blocks of building stones, and nearly 200 specimens of polished marble and other ornamental stones: (*l*) An extensive collection of ores and other economic minerals, filling 80 drawers and 25 feet of glass case.

2. A room in the basement is used in part for the blowpipe work in Determinative Mineralogy. It is supplied with tables, Bunsen-

burners, agate mortars, and other accessory apparatus accommodating classes of twenty-four students each.

The minerals used are arranged in ten series of specimens, representing sixty species in each, and classified in eighty wooden trays.

3. The Geological Library and Laboratory, Room 14, Rogers Building. This room is likewise used as a recitation-room for a few of the smaller and more advanced classes. It contains the Rogers Geological Library of about thirteen hundred bound volumes and several hundred pamphlets; also, the current numbers of eight of the leading serial publications. In the cases are two hundred drawers of specimens of fossils and rocks, stratigraphically arranged. There is also an exhibition case of specimens arranged in like manner, and a case of eighteen large drawers filled with maps, sections, and drawings. The room is well supplied with tables at which students pursue their studies in stratigraphical palæontology and micro-lithology. Geological maps and sections are drawn, and field notes are revised, and the results of investigations are here prepared for final presentation.

VIII. **The Mechanical Laboratories, or Workshops.** A separate circular has been printed in connection with the exhibit of the Institute, giving a statement of the system of instruction in the Mechanic Arts, and an account of the workshops, or mechanical laboratories, and their equipment, which it is not necessary to repeat here.

## ENDOWMENT.

The Massachusetts Institute of Technology is unfortunately still an unendowed institution, in the sense that its receipts from invested property constitute but a very small part of the means required to carry on the service of the school.

First and last, about a million and a half dollars have been given or bequeathed to the school, some part of which it has been absolutely necessary to use for current maintenance. Of the amount mentioned, the State of Massachusetts gave $200,000, one half of which was free of conditions, the other half being for the support of free scholarships.

The two principal contributors to the funds of the Institute in its earlier days were Dr. Wm. J. Walker and Mr. Ralph Huntington. The principal contributors of late years have been Messrs. George B. Dorr, Richard Perkins, Jerome S. Kidder, Mrs. Henry Edwards, and Mrs. Catherine P. Perkins.

The amount of income-yielding property held by the Institute is $504,403.75. The buildings occupied by the Institute stand on the books of the Treasurer at $707,926.85; the land at $127,155.69.

Architectural Department; Free-Hand Drawing-Class.

In addition to the land thus held in fee, the Institute enjoys the right of perpetual occupancy, by grant from the Commonwealth of Massachusetts, of the land upon which the Rogers and Walker Buildings stand.

The equipment of the several buildings and their laboratories, including the libraries, the accumulations of twenty-eight years, represents an expenditure of probably about $200,000.

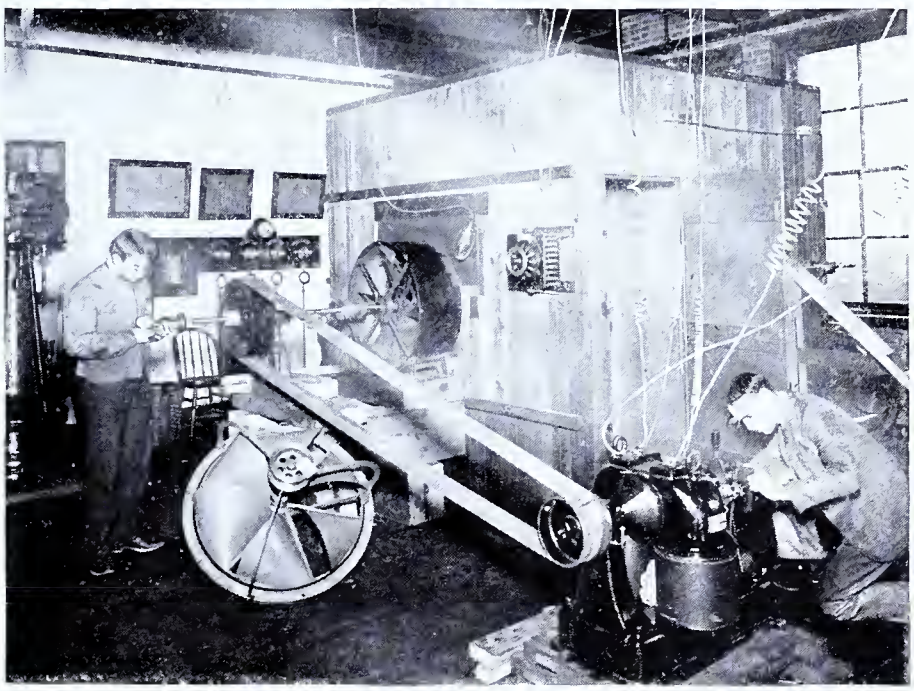
The net annual income from invested funds is about $25,000.

The income from students' fees last year (1891–92) was $185,873.77.

The Institute receives one third of the national grants to the State of Massachusetts under the United States Acts of 1862 and 1890, amounting at present to about $12,000 a year.

It has also a certain income from rents and other sources, making the total receipts (1891–92) $264,285.78.

The expenditures for the same year amounted to $267,547.90, leaving a deficit for the year of a little over $3,000. Of the total expenditures $180,667.94 was for salaries.



Tests on Ventilating Fans.